

Sandia National Laboratories

Albuquerque, New Mexico 87185

date: January 17, 1990

to: Paul J. Hommert, 6258



from: Billy Joe Thorne, 6258

subject: Location of Point Pedernales SEMS Unit

In his memo of January 9, 1990, G. E. Sleafy suggests that a more detailed analysis of the soil/pile/structure interaction problem be undertaken to estimate the level of radiated noise to be expected close to Platform Irene. While it would be prohibitively expensive to model the entire soil/pile/structure interaction problem in a finite element code, it is possible to model an axisymmetric approximation to a single pile using the two-dimensional finite element code PRONTO.

Figure 1 illustrates the finite element grid used in these calculations. The pile is modeled as an acceleration boundary condition applied to the top 460 ft. (140 m) of the left edge of the finite element grid. This portion of the finite element grid is indented from the axis of symmetry by 2.5 ft. (0.762 m), corresponding to the pile radius. The top layer represents 240 ft. (73 m) of water. Figure 1 shows the 10 ft. (3 m) square elements used to represent the top layer of seabed soil, which is modeled as 60 ft. (18 m) thick. A second layer of slightly firmer soil, 30 ft. (10 m) thick, sits on top of a base of firm soil which terminates in a transmitting boundary condition at a depth of 800 ft. (244 m) below sea level. A transmitting boundary condition is applied to the right edge of the finite element grid at a radius of 1,002.5 ft. (306 m). All elements are 10 ft. (3 m) square except for those directly below the pile which are 2.5 ft. by 10 ft. (0.762 m by 3 m).

The water is modeled as an energy-independent hydrodynamic material with a density of 62 lb/ft³ (1,000 kg/m³) and a sound speed of 4,921 ft/s (1,500 m/s). The three soil layers correspond to layers A, B and C of the McClelland engineers report to Union Oil on the Subsurface Investigation of Platform Irene, OCP P-0441, Point Pedernales Offshore, California. Soil densities are taken to be the average of samples for each layer. Elastic properties are assumed for each layer, even though the data clearly indicate that all three layers exhibit significant nonlinear behavior. The elastic assumption should result in an over estimate of the radiated signal, since nonlinear effects would result in damping not modeled in the elastic assumption. The nonlinear nature of the data leave a wide range of possible choices for the elastic approximation.

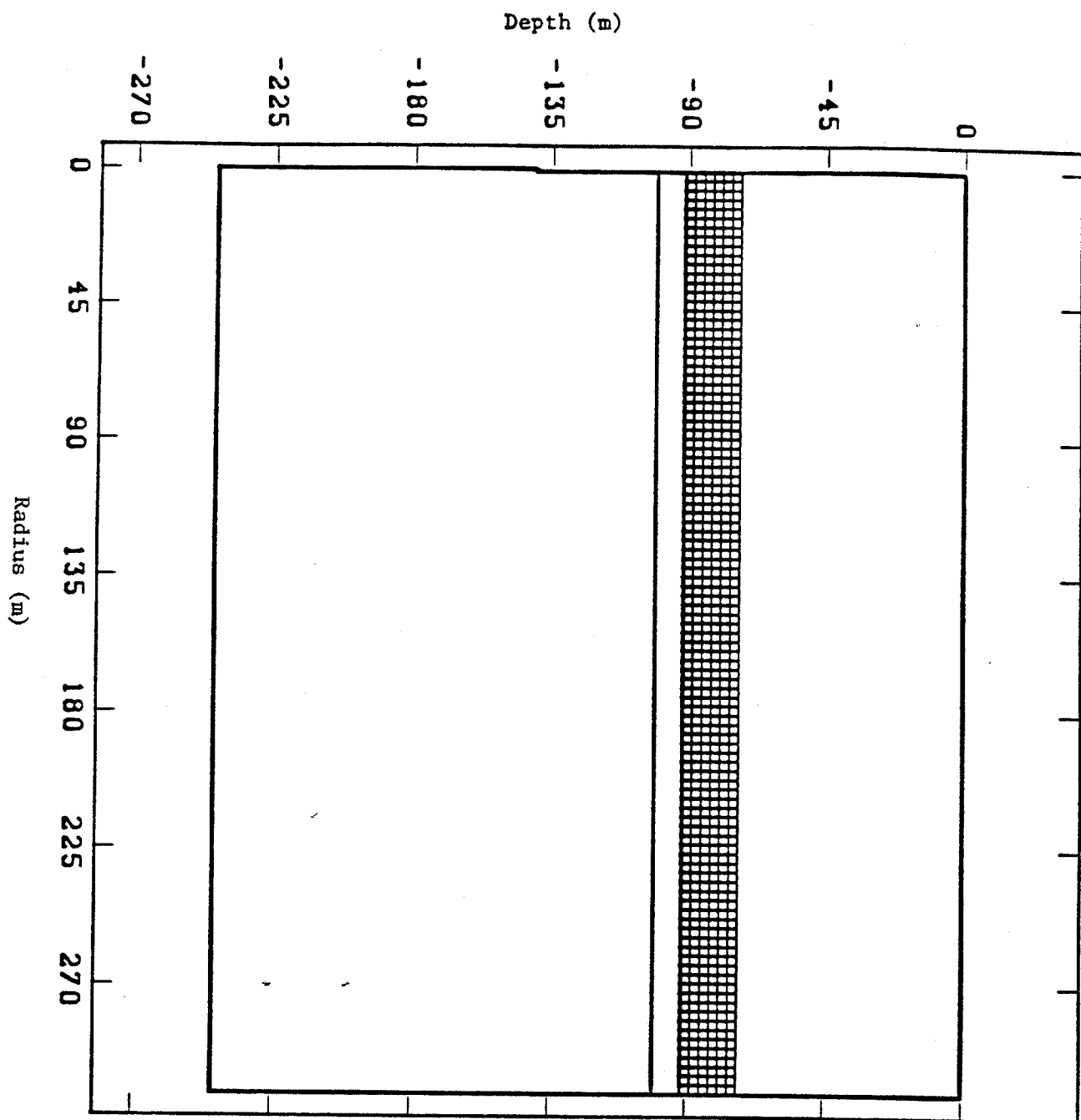
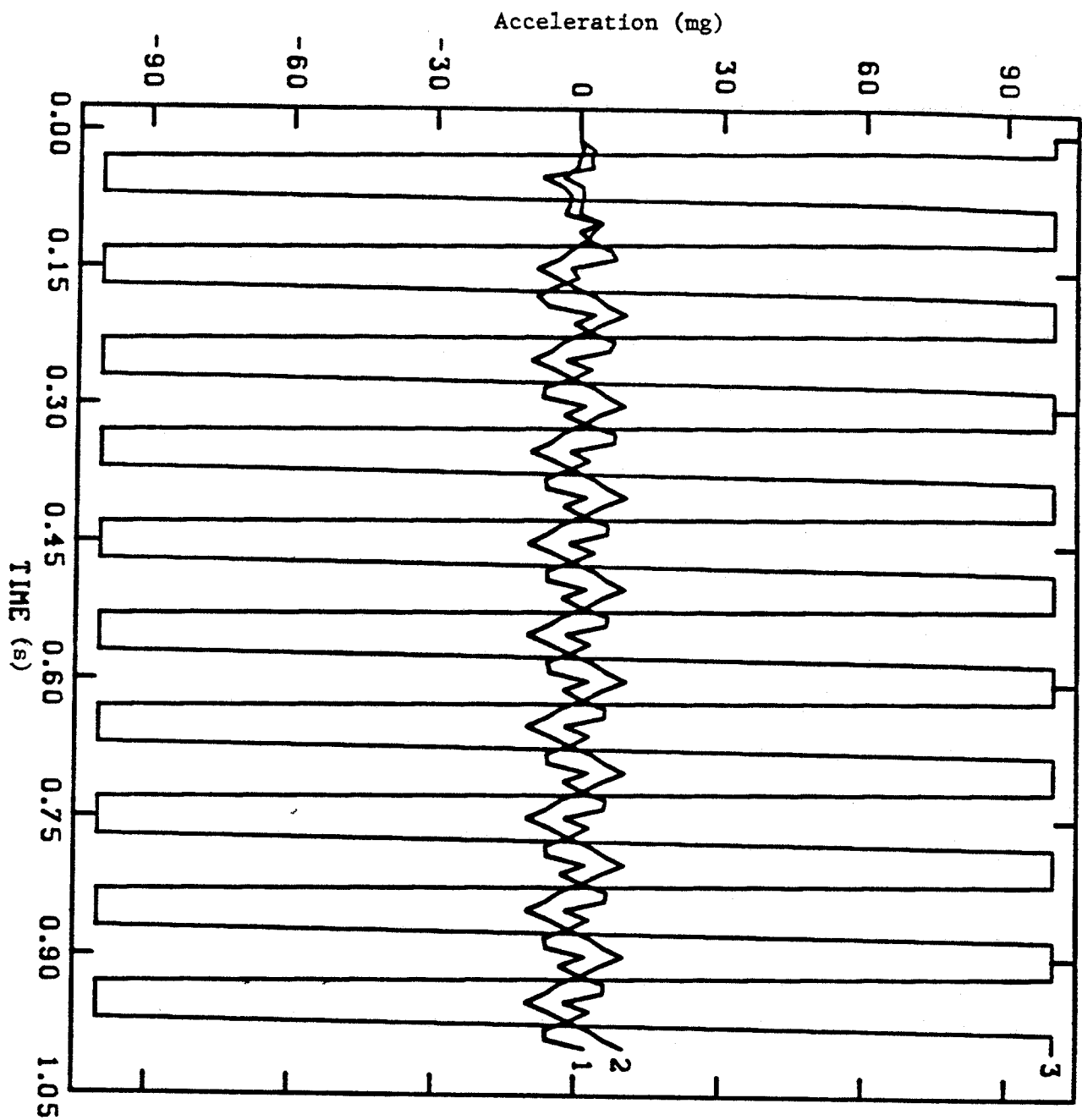
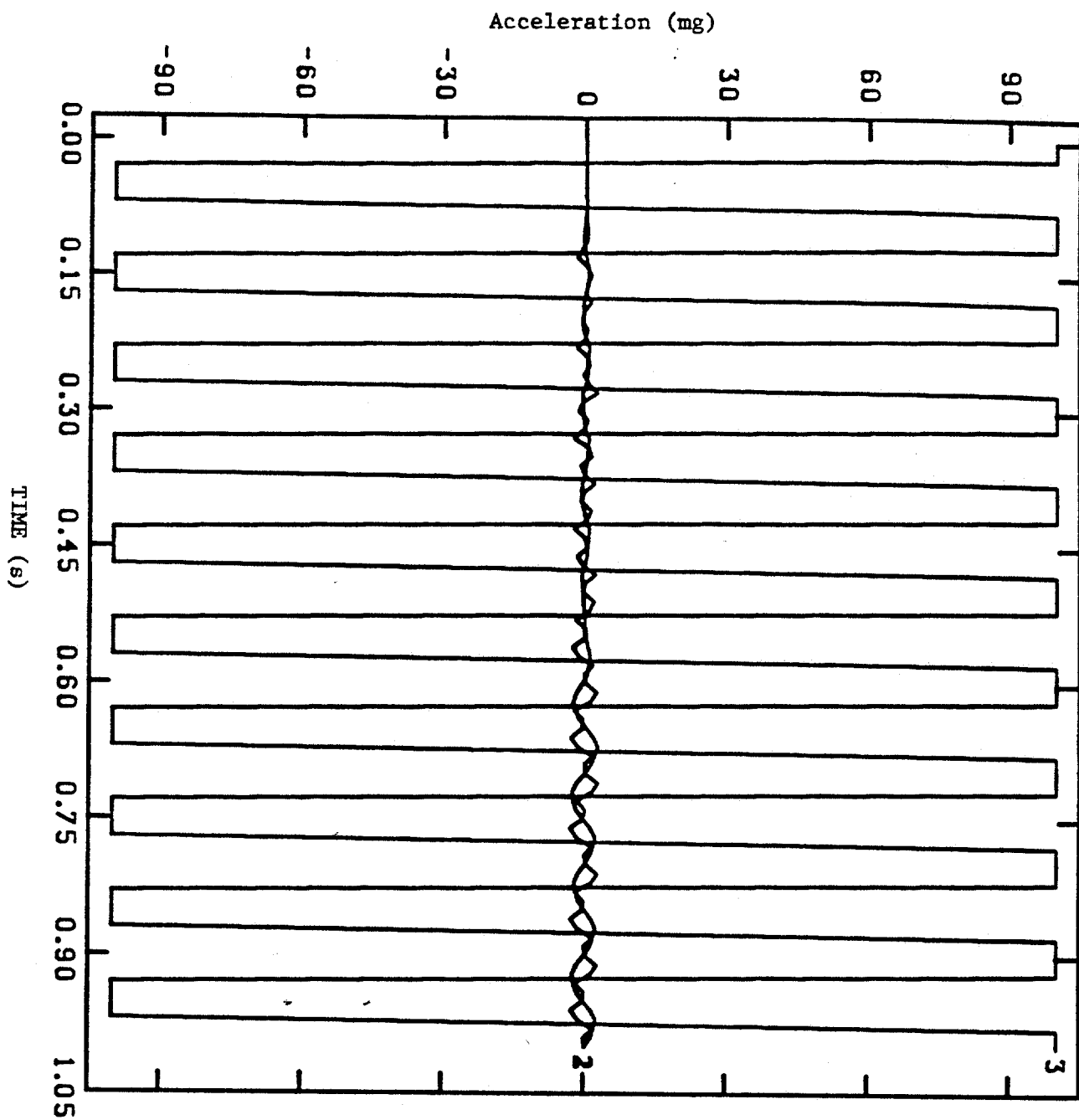


FIGURE 1 - FINITE ELEMENT GRID



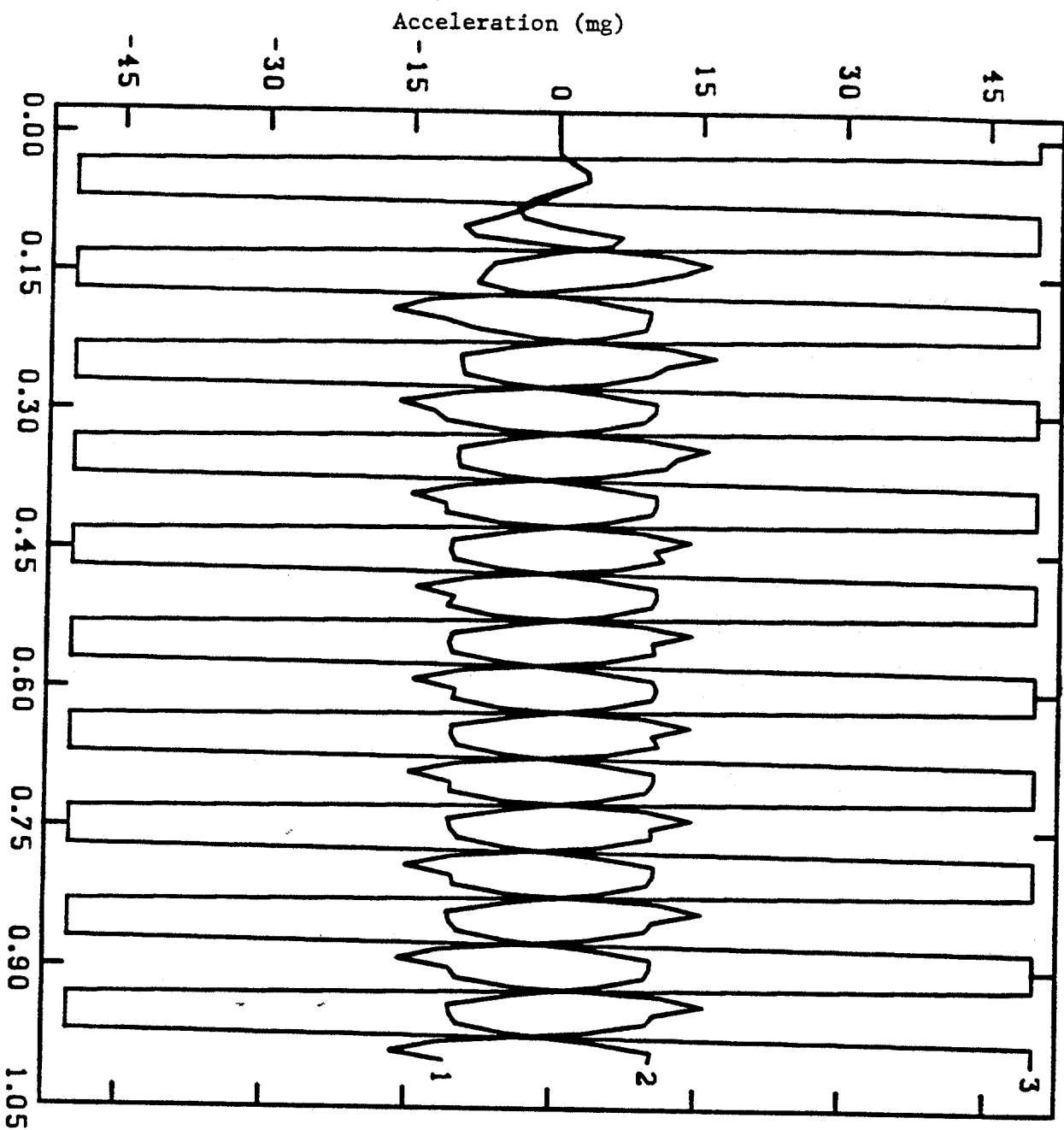
1. Horizontal Acceleration
2. Vertical Acceleration
3. Boundary Acceleration

FIGURE 2 - 10Hz SQUARE WAVE 100mg HORIZONTAL ACCELERATION AND RESPONSE
10 ft. BELOW SEABED, 100 ft. FROM PILING



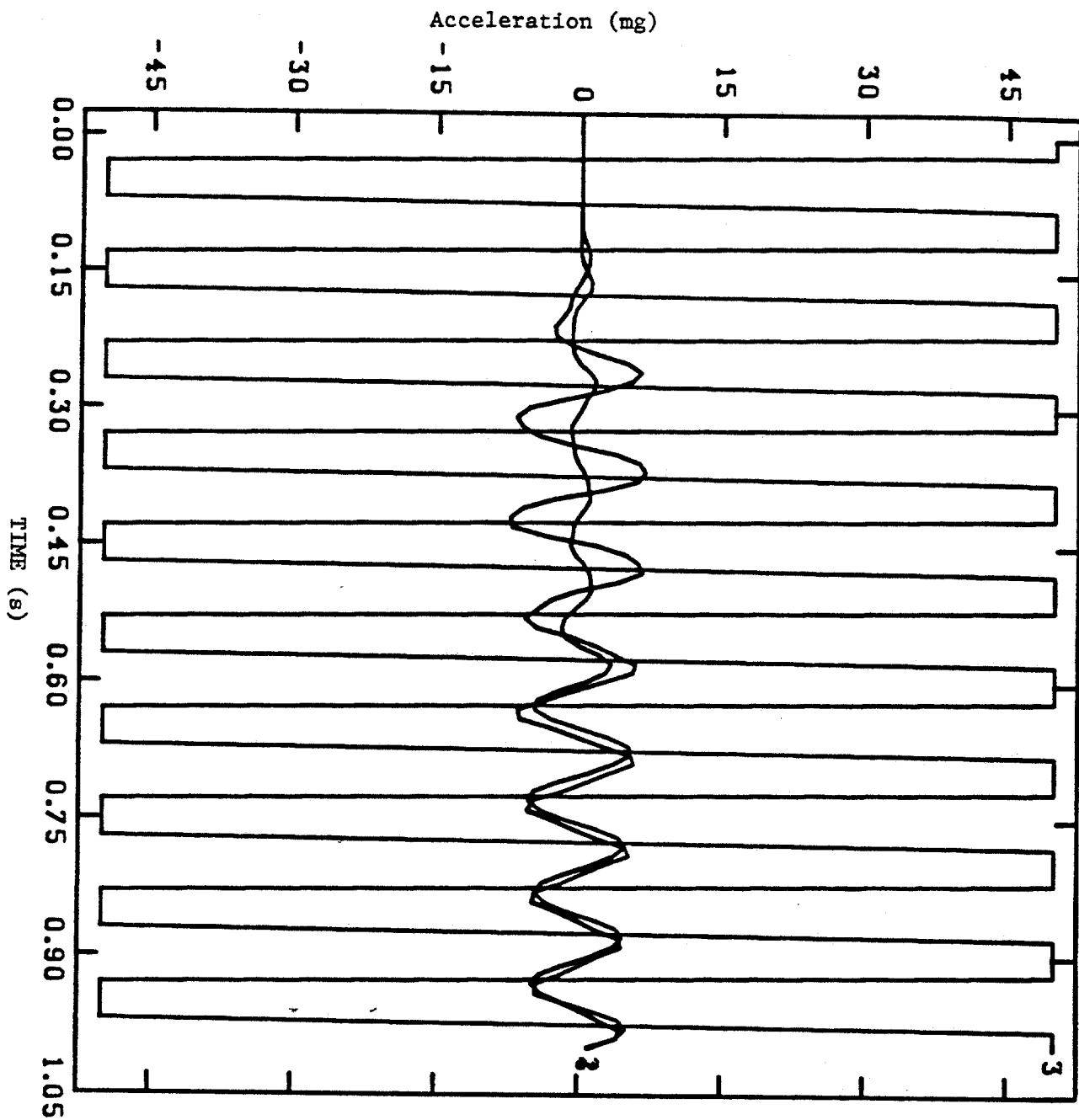
1. Horizontal Acceleration
2. Vertical Acceleration
3. Boundary Acceleration

FIGURE 3 - 10Hz SQUARE WAVE 100mg HORIZONTAL ACCELERATION AND RESPONSE
10 ft. BELOW SEABED, 500 ft. FROM PILING



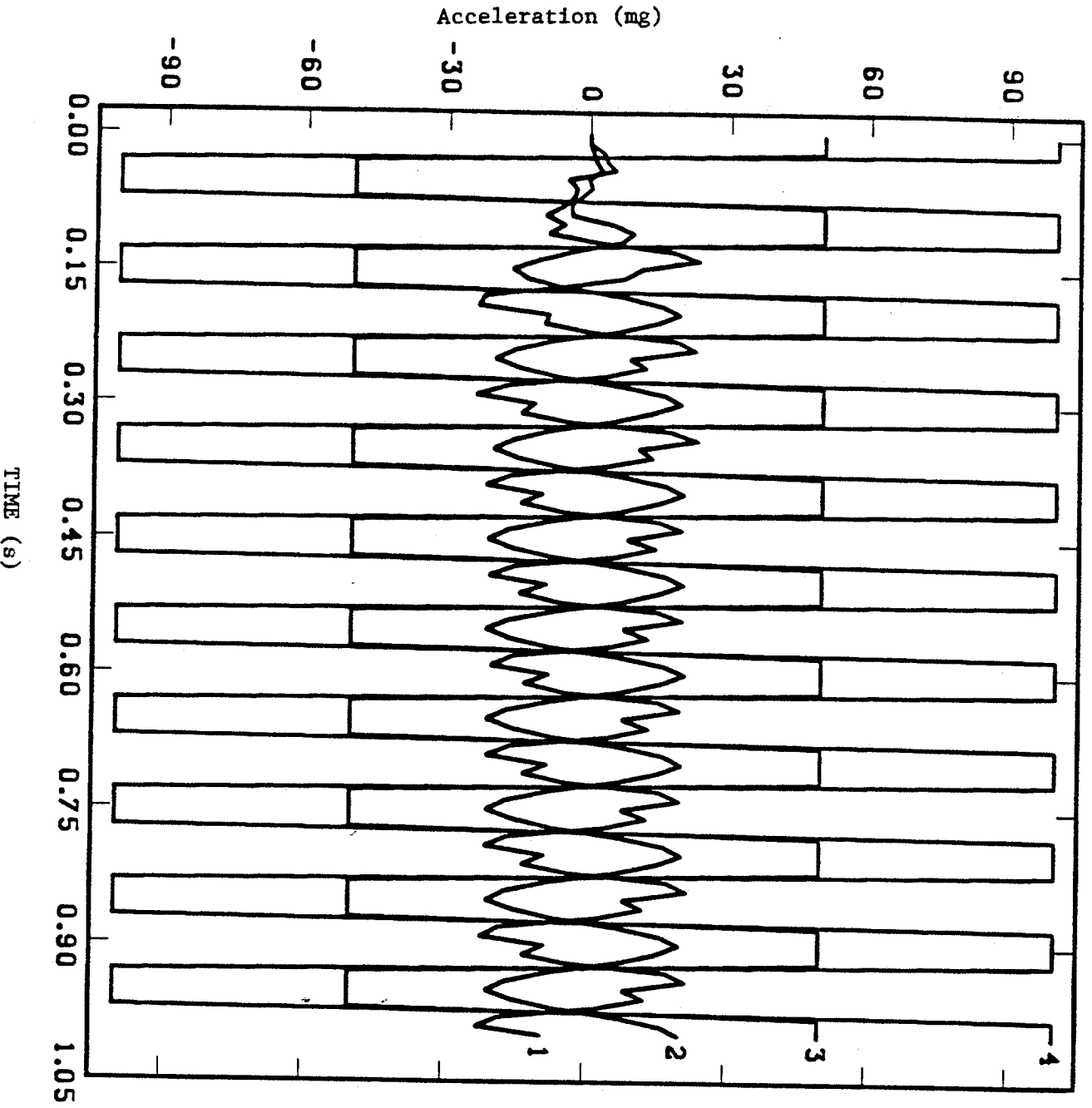
1. Horizontal Acceleration
2. Vertical Acceleration
3. Boundary Acceleration

FIGURE 4 - 10Hz SQUARE WAVE 50mg VERTICAL ACCELERATION AND RESPONSE
10 ft. BELOW SEABED, 100 ft. FROM PILING



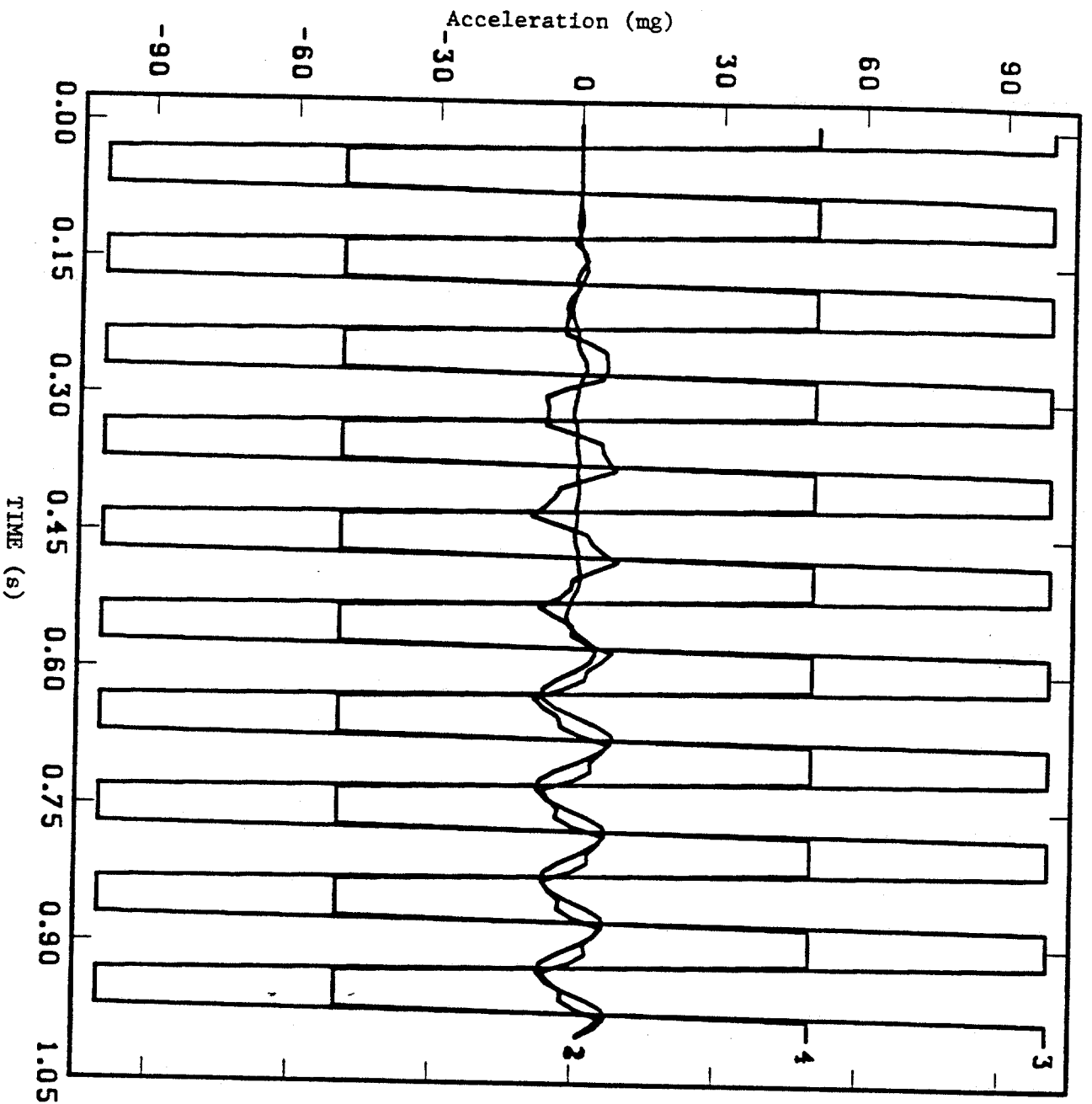
1. Horizontal Acceleration
2. Vertical Acceleration
3. Boundary Acceleration

FIGURE 5 - 10Hz SQUARE WAVE 50mg VERTICAL ACCELERATION AND RESPONSE
10 ft. BELOW SEABED, 500 ft. FROM PILING



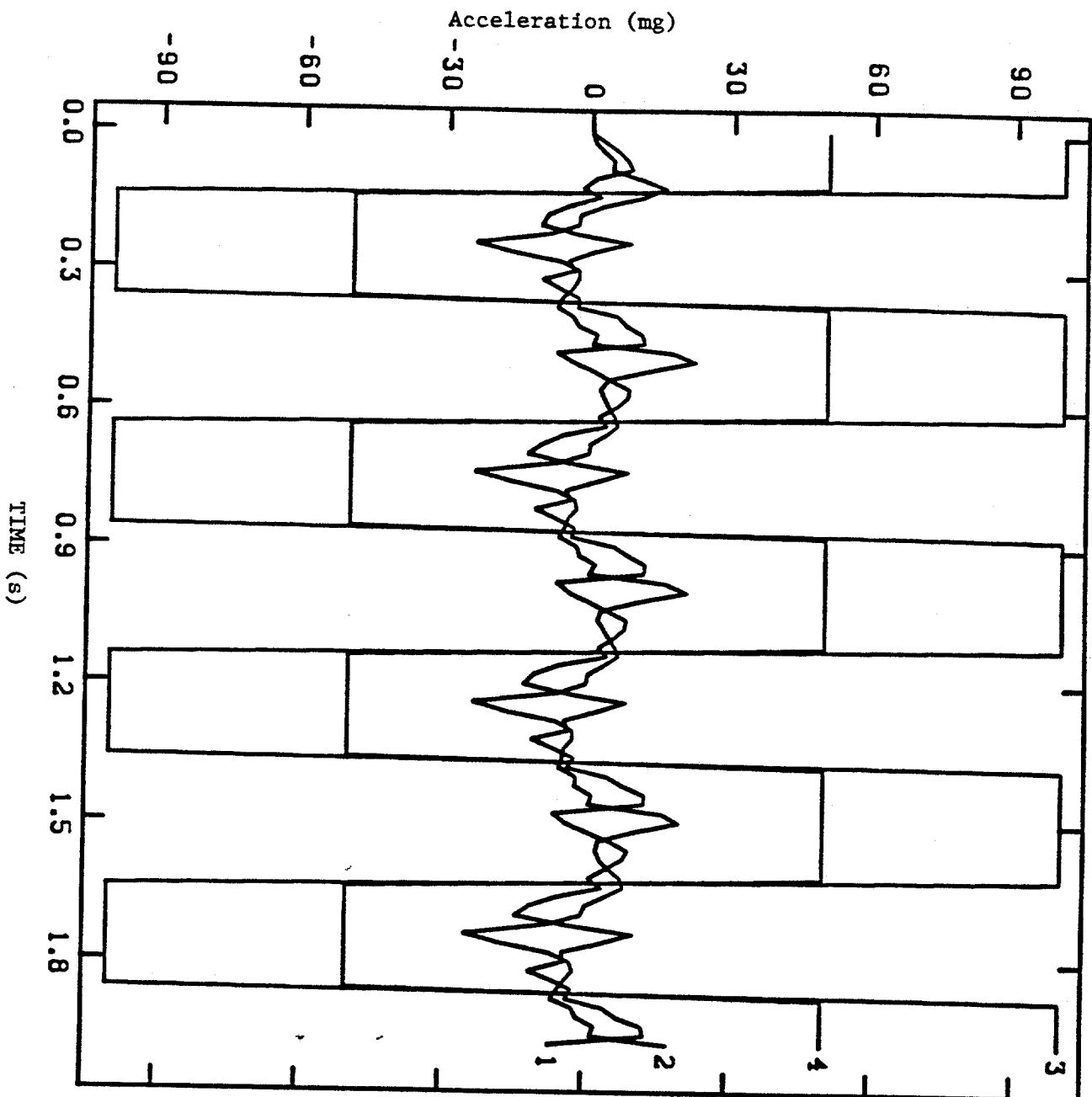
- 1. Horizontal Acceleration
- 2. Vertical Acceleration
- 3. Vertical Boundary Acceleration
- 4. Horizontal Boundary Acceleration

FIGURE 6 - 10HZ SQUARE WAVE 100mg HORIZONTAL AND 50mg VERTICAL ACCELERATION
RESPONSE 10 ft. BELOW SEABED, 100 ft. FROM PILING



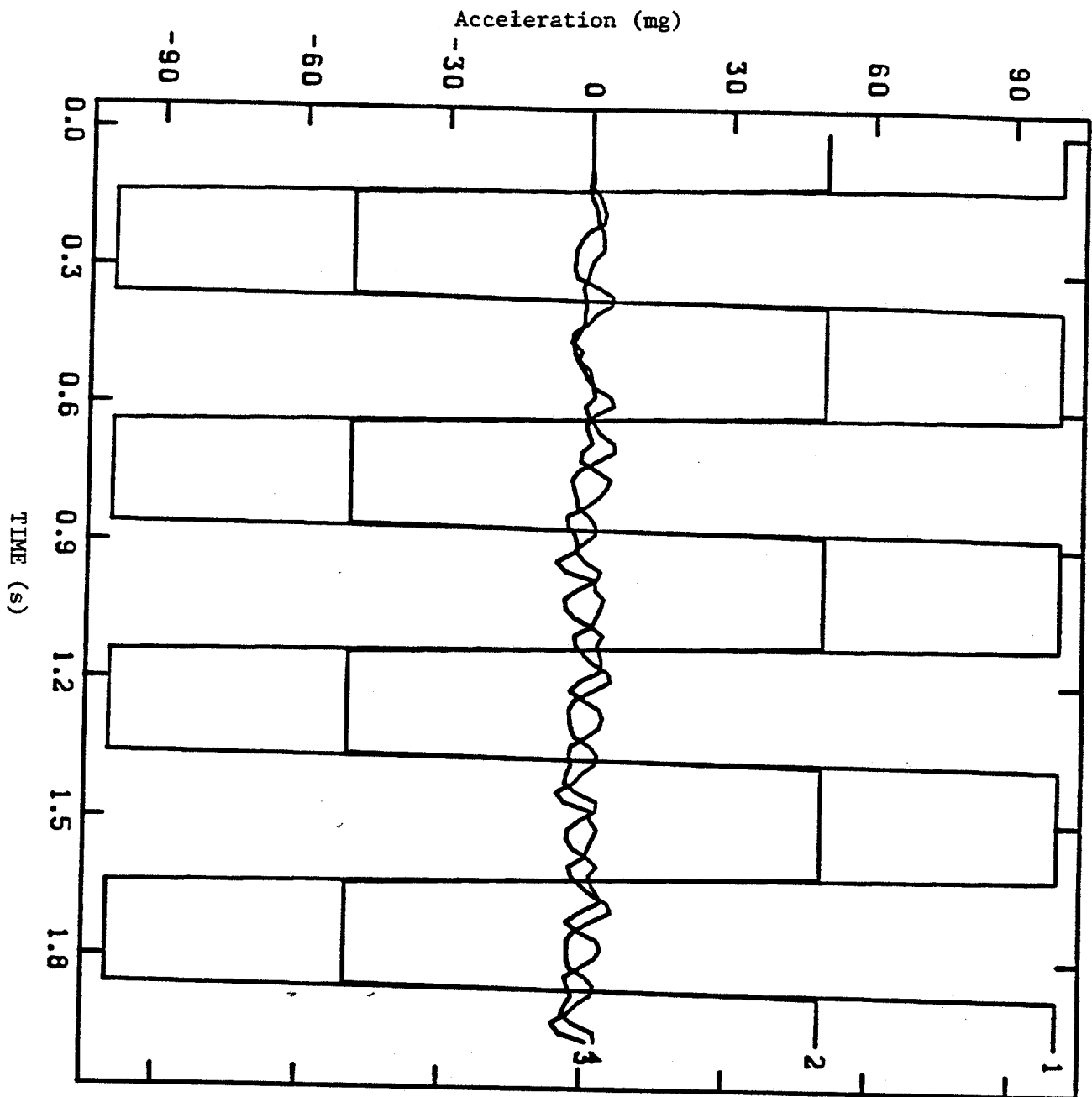
1. Horizontal Acceleration
2. Vertical Acceleration
3. Vertical Boundary Acceleration
4. Horizontal Boundary Acceleration

FIGURE 7 - 10Hz SQUARE WAVE 100mg HORIZONTAL AND 50mg VERTICAL ACCELERATION
RESPONSE 10 ft. BELOW SEABED, 500 ft. FROM PILING



1. Horizontal Acceleration
2. Vertical Acceleration
3. Horizontal Boundary Acceleration
4. Vertical Boundary Acceleration

FIGURE 8 - 2Hz SQUARE WAVE 100mg HORIZONTAL AND 50mg VERTICAL ACCELERATION
RESPONSE 10 ft. BELOW SEABED, 100 ft. FROM PILING



1. Horizontal Boundary Acceleration
2. Vertical Boundary Acceleration
3. Horizontal Acceleration
4. Vertical Acceleration

FIGURE 9 - 2Hz SQUARE WAVE 100mg HORIZONTAL AND 50mg VERTICAL ACCELERATION
RESPONSE 10 ft. BELOW SEABED, 500 ft. FROM PILING

For these calculations, the top layer of soil was modeled with a density of 119 lb/ft³ (1,910 kg/m³), a Poisons ratio of 0.47, and a sound speed of 5,075 ft/s (1,547 m/s). The second layer was given a density of 121 lb/ft³ (1,942 kg/m³), a Poisons ratio of 0.48, and a sound speed of 6,430 ft/s (1,960 m/s). The third layer was modeled with a density of 122lb/ ft³ (1,958 kg/m³). Poisons ratio and sound speed for this layer were based on data at 487 ft. (148 m) below sea level and were taken to be 0.35 and 8,911 ft/s (2,716 m/s) respectively.

In the first calculation, a 10 Hz square wave horizontal acceleration of 100 mg (Figure 2, Curve 3) was applied to the boundary nodes along the length of the piling. The resulting acceleration 10 ft. (3 m) below the seabed-water interface, at a radius of 100 ft. (30 m), is less than 9 mg in both components (Figure 2, Curves 1 & 2). At a radius of 500 ft. (152 m), the peak acceleration 10 ft. (3 m) below the seabed-water interface has dropped to less than 3 mg (Figure 3, Curves 1 & 2).

In the second calculation a 10 Hz square wave vertical acceleration was applied to the boundary nodes along the length of the piling. Since the vertical amplification of earthquake motion is expected to be less than half of the horizontal amplification, the amplitude of the vertical load was taken to be 50 mg. This load (Figure 4, Curve 3) results in accelerations at the 10 ft. (3m) depth and 100 ft. (30 m) radius which exceed 13 mg (Figure 4, Curves 1 & 2). Even at a 500 ft. (152 m) radius the response at the 10 ft. (3 m) depth exceeds 8 mg (Figure 5, Curves 1 & 2). This confirms Sleaf's predictions that vertical amplification will be much more effective in generating noise than horizontal amplification and that 50 ft. from the platform is probably too close to avoid significant radiated energy.

In the third calculation, a 10 Hz square wave was applied with a horizontal acceleration of 100 mg and a vertical acceleration of 50 mg (Figure 6, Curves 3 & 4). For this load, the response at the 10 ft. (3 m) depth exceeded 20 mg at the 100 ft. (30 m) radius (Figure 6, Curves 1 & 2), but dropped to less than 8 mg at the 500 ft. (152 m) radius (Figure 7, Curves 1 & 2).

In a final calculation, the frequency of the square wave load was changed to 2Hz (Figure 8, Curves 3 & 4). This resulted in peak accelerations at the 10 ft. (3 m) depth and 100 ft. (30 m) radius in excess of 20 mg (Figure 8, Curves 1 & 2), as with the 10 Hz loads. However, at the 500 ft. (152 m) radius the response at the 10 ft. (3m) depth was less than 6 mg (Figure 9, Curves 3 & 4).